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LOW-TEMPERATURE PLASMA

Numerical Study of the Voltage Waveform Effect on the Spatiotemporal Characteristics of a Dielectric Barrier Microdischarge in Argon

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Abstract—The effect of the shape of the feeding voltage on the spatiotemporal characteristics of an atmospheric-pressure barrier microdischarge in argon is demonstrated using numerical simulations based on an extended fluid model. Results of simulations performed for sinusoidal and square feeding voltages are analyzed.

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1. INTRODUCTION

Dielectric barrier glow discharges have been known for a rather long time. The renewed interest in this type of discharge stems from the fact that dielectric barrier discharges (DBDs) at pressures close to atmospheric one have a wide range of applications—from plasma aerodynamics to plasma medicine and plasma decomposition of gaseous substances [1–11]. Small spatiotemporal scales of atmospheric-pressure DBDs impede their direct experimental study. The discharge parameters are judged from the measured integral characteristics (in particular, the current and voltage waveforms), optical measurements, etc. In practice, however, it is often useful to know the spatiotemporal characteristics of the discharge plasma, such as the distribution of the electric field, the densities of charged and excited particles, and others. Therefore, there is a necessity in performing numerical simulations of discharge processes. However, numerical simulations do not always provide a complete picture of the processes occurring in a DBD. As a rule, a particular aspect that is significant for a specific problem is modeled. For example, an individual barrier microdischarge is simulated under the assumption that all microdischarges of the series are identical and do not affect one another. The one-dimensional (see, e.g., [12]) and two-dimensional (e.g., [13, 14]) discharge models with different levels of detailing of plasmachemical processes in fact ignore the processes occurring on the dielectric surface. To a great extent, the accuracy of the applied mathematical model is determined by the uncertainty in the initial data (the reaction cross sections, distribution functions, etc.) and the completeness of the plasmachemical model.

The possibility to control the DBD parameters is of great practical importance. In addition to the influence of the frequency and amplitude of the feeding voltage, experimental studies of the effect of the shape of the feeding voltage on the discharge characteristics are very challenging [9–11]. As for publications devoted to numerical analysis of the effect of the shape of the feeding voltage on the spatiotemporal characteristics on the DBD, they are very scarce in number (see, e.g., [15]).

The aim of the present work was to numerically analyze the effect of the shape of the feeding voltage on the spatial and temporal characteristics of a DBD in argon. Two waveforms of the feeding voltage were considered: sinusoidal and square ones.

2. MODEL

The spatiotemporal characteristics of the DBD were determined using an extended fluid model describing the parameters of the gas-discharge plasma [16, 17]. The model is based on the drift-diffusion equations and includes k equations for the densities of charged (electrons, ions) and excited particles n_k and the balance equation for the electron energy density n_ε. The self-consistent electric field is determined